UNCLASSIFIED

AD NUMBER

AD079771

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; NOV 1955. Other requests shall be referred to Army Engineer Waterways Experiment Station, Vicksburg, MS.

AUTHORITY

AEWES ltr dtd 29 Mar 1973

THIS PAGE IS UNCLASSIFIED

CORPS OF ENGINEERS, U. S. ARMY

SUMMARY OF INVESTIGATIONS OF EFFECTS OF JET BLAST, FUEL SPILLAGE, AND TRAFFIC ON EXPERIMENTAL TAR-RUBBER-CONCRETE PAVEMENTS

VICKSBURG, MISSISSIPPI

NOVEMBER 19[illegible]

AD 079771

CORPS OF ENGINEERS, U. S. ARMY

SUMMARY OF INVESTIGATIONS OF EFFECTS OF JET BLAST, FUEL SPILLAGE, AND TRAFFIC ON EXPERIMENTAL TAR-RUBBER-CONCRETE PAVEMENTS

TECHNICAL MEMORANDUM NO. 3-420

PREPARED FOR

OFFICE OF THE CHIEF OF ENGINEERS

AIRFIELDS BRANCH

ENGINEERING DIVISION

MILITARY CONSTRUCTION

BY

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

ARMY-MRC VICKSBURG, MISS.

NOVEMBER 1955

Best
Available
Copy

Contents

	Page
Introduction	[illegible]
Laboratory Investigations	2
Field Tests	6
Summation of Findings	12
Conclusions	15
Appendix A: Interim Specification for Tar-rubber Blend for Use as Binding Agent in Hot-mix Tar-rubber Pavement	A1

SUMMARY OF INVESTIGATIONS OF EFFECTS OF JET BLAST, FUEL SPILLAGE, AND TRAFFIC ON EXPERIMENTAL TAR-RUBBER-CONCRETE PAVEMENTS

Introduction

1. This summary presents the results of investigations conducted by the Corps of Engineers to date (July 1955) relative to the performance of tar-rubber paving surfaces under simulated and actual jet aircraft operations.* Since the advent of jet-propelled aircraft, the U. S. Air Force has been concerned with requirements necessary for construction of aircraft landing facilities to withstand the effects of jet blast, fuel spillage, and high-pressure-tire traffic on the surfaces of runways, taxiways, and aprons. As a result, the Corps of Engineers, in conjunction with the U. S. Air Force, initiated a comprehensive investigational program in 1952 to determine the ability of tar-rubber-concrete pavement to withstand the distress that jet-type aircraft sometimes cause to certain types of bituminous surfaces.

2. A laboratory investigation of tar-rubber materials and mixes was undertaken at the Waterways Experiment Station in 1952. Field test sections have been constructed and tested at the following locations to compare the merits of asphaltic concrete and tar-rubber concrete: Hunter Air Force Base, Georgia, in 1952; Presque Isle Air Force Base, Maine, in 1952; and Waterways Experiment Station in 1953. Tar-rubber-concrete pavements were built in October 1953 at McChord Air Force Base, Washington, and Davis-Monthan Air Force Base, Arizona, and observations have been made of the effect of jet-aircraft operations on these pavements. In addition, blast tests with a new type jet fighter plane were made on the tar-rubber pavements at Davis-Monthan Air Force Base. Reports on construction of the test pavements at Hunter, Presque Isle, McChord, and Williams, Arizona, Air Force Bases have been issued by the Corps of

* This technical memorandum includes and supersedes Miscellaneous Paper 4-116 of the same title, dated February 1955.

similar tests. These tests were conducted on the tar-rubber blends and on paving grades of tar and asphalt; the tests on paving grades of tar and asphalt served as control tests by which to judge the results of tests on the tar-rubber blends. Marshall stability tests at vari , temperatures were also conducted on compacted test cores prepared from paving mixes of the various binders.

6. As a result of these studies of temperature susceptibility it appeared that the addition of rubber to tar had the following favorable effects as compared to straight tar: (a) higher softening point, (b) increased viscosity, and (c) very slightly increased stability (Marshall test) at elevated temperatures. No advantage over tar was apparent on the following points: (a) flow properties, and (b) rate of hardening or softening with change in temperature. Subsequent studies, however, indicate some improvement in flow properties also. Prediction as to whether the tar-rubber compounds would function adequately in the prototype was not possible from these laboratory tests, but there was reason to believe that the tar-rubber blends were superior to straight tar from the temperature-susceptibility standpoint.

<u>Jet-fuel resistance tests</u>

7. One of the principal objectives of the laboratory study was to determine how tar-rubber pavement mixes compare with mixes containing straight tar or penetration-grade asphalt cement from the standpoint of resistance to the action of jet fuel. In order to investigate this question, laboratory cores were prepared from mixes containing each of the following binders: tar-rubber compounds, straight tar, and asphalt cement. Jet fuel was then poured over these cores once each hour for a period of time while they were subjected to outdoor exposure. In these tests, the tar-concrete and tar-rubber-concrete showed good fuel resistance, but the asphaltic concrete was not resistant.

Establishment of tentative design test procedures

8. The results of the tests for temperature susceptibility and jet-fuel resistance indicated that the rubberized tars showed sufficient promise to warrant developing mix design procedures for selecting optimum

binder (tar-rubber) contents. It had become apparent in earlier investigations with tar pavements that some modifications of the standard test procedures for designing asphalt pavements would be required when a tar or tar-rubber blend was used as the binding agent in the paving mix. In setting up the procedure for determination of the optimum binder content for tar and tar-rubber mixes, it was desired to follow the same general scheme that had already been established for asphalt-cement mixes, i.e., averaging laboratory test values at: peak of unit weight curve, peak of stability curve, a certain specified per cent air voids, and a certain specified per cent voids filled. The first series of tests with tar and tar-rubber, however, showed that when these materials were prepared and tested at the temperatures normally used for asphalt cement neither the compaction nor the stability curves developed a peak; further testing revealed that these curves did develop peaks if the test temperatures were reduced sufficiently. The basic reasoning in adjusting the test temperature was that the viscosity of the materials when tested at the adjusted temperatures should be close to that of asphalt cement at standard test temperatures. Preliminary tests at different temperatures indicated that it should be possible to set a tentative laboratory procedure by deliberately adjusting test temperatures to cause a predetermined "reasonable" optimum value to be obtained on a given typical mix. Actually this is the procedure that was followed: the temperatures have been adjusted leaving all other phases of the design test the same and as currently specified for penetration-grade asphalt cement. The test temperatures for tar-rubber are as follows:

Mixing Temperature			
Aggregate	Binder	Compaction	Stability
250 ± 5 F	225 ± 5 F	200 ± 5 F	120 ± 1 F

The compaction temperature for control tests must, of course, correspond to that used in preparing the design test specimens (200 ± 5 F).

9. The "reasonable" optimum and the test temperatures were selected on the basis of the following:

a. Information contained in Chapter 2, Part XII, of the

Engineering Manual for Military Construction.

b. Technical information furnished by the manufacturers of rubberized tars.

c. Information contained in handbooks on tar.

d. Information contained in various published articles tar-rubber pavements.

e. Information from the South Atlantic Division, Corps of Engineers, on the tar-rubber test strips at Hunter Air Force Base.

f. Previous experience with asphalt and tar.

g. Results of rather intensive laboratory tests at the Waterways Experiment Station.

10. The procedures that were set up as a result of this investigation are for guidance in the tar-rubber pavement mix design and are subject to modification on the basis of future field experience. These procedures were not available for use in designing mixes at Hunter Air Force Base but have been used in all subsequent tar-rubber pavement work. To date, experience indicates that this procedure gives approximately the correct optimum bitumen content where the pavement is subjected to fuel spillage.

Extraction test procedure

11. The following procedure is recommended for extractions:

a. Soak sample in crystal-free creosote overnight. (A suitable crystal-free creosote is manufactured by Koppers Company, Inc., Koppers Bldg., Pittsburgh 19, Pennsylvania, under the trade name "Kolineum.")

b. Transfer soaked sample and Kolineum to Rotarex and centrifuge to remove Kolineum.

c. Wash sample with benzene until solvent is light straw color.

d. Conduct ash correction on solvent in the usual manner

Specification tests for tar-rubber compounds

12. The Waterways Experiment Station has prepared a tentative set of acceptance tests for tar-rubber blends based on data and experience available to date. This specification is suitable for receiving bids at

this time but is not yet considered to be in a final form. It is included as appendix A hereto.

Field Tests

Procedures

13. The three principal field tests conducted in this investigation were high-pressure tire traffic, jet blast, and repeated fuel spillage (JP-4 fuel). The procedure for traffic testing has long been established and in the study at the Waterways Experiment Station consisted of 1500 coverages of a 100,000-lb, dual-wheel load with tires inflated to 200 psi. It is known that all pavements on airfields must be designed to withstand the contemplated traffic whether for jet or propeller-type aircraft, whereas only specific facilities must be designed to withstand the effects of jet blast and fuel spillage. It was for these two effects that special test procedures had to be developed.

14. Time-movement studies at active bases were made in 1951-52 to determine specific operational procedures used for jets. It was found that only blasts made while the planes were standing still were significant and these occurred on parking areas (various types of aprons) and runway ends. The longest and most severe exposure condition was found in the parking area where engine maintenance checks were made. The blast cycle for pretake-off at the runway end was found to be less severe than the maintenance cycle, and that for starting was least severe. Therefore, the most severe type of blast (designated maintenance run-up) was utilized in most of the tests connected with the tar-rubber investigation. The power cycle was generally 5.5 minutes at idle power followed by 1.5 minutes at 100 per cent engine power (known as military power when plane has afterburner) and repeated as many as three times. For the new type fighter plane, another power cycle of similar duration was also used to provide 1.5-minute periods at 100 per cent engine power plus afterburner (known as full power). In addition, pretake-off runs were made with this plane because the afterburner is cut on at the moment the plane starts to move. Thus, primary considerations are

pretake-off runs at runway ends and the longer maintenance runs on parking areas.

15. A survey of jet operations on parking aprons at three active bases provided the necessary information for establishing test procedures to simulate fuel spillage. Little or no spillage was seen on taxiways or runway ends. It was also found that damage occurred to asphaltic pavements only when the spillage was repeated in the same spot. Therefore, spillage occurrences were divided into "incidental spillage" and "repeated spillage." It was found that fuel was spilled at the parking spot each time the jet engine or engines were cut off. The amount of fuel spilled was a maximum of 1 qt for each engine cut off and the number of cut offs averaged four per day, five days per week. This procedure, hereafter referred to as repeated spillage, was adopted for test purposes. The fuel was spilled from a height of 30 in. within a period of two minutes. In addition, spillage at the rate of one and two cycles per day was accomplished to determine the effect of incidental spillage or that approaching what might happen in refueling operations. It should be pointed out that spillage is considered as a problem only for parking areas.

Hunter Air Force Base tests

16. Jet-blast tests and spillage tests were performed at Hunter Air Force Base but are generally discounted because construction procedures were improved so much following this first trial that the pavements are not considered typical of later tar-rubber pavements.

Presque Isle Air Force Base tests

17. Jet blast. Using an F-80-C plane, 14-minute maintenance blasts as described in paragraph 14 above were made on each of four types of surfaces: (a) asphaltic concrete (100-120 penetration), (b) tar concrete (RT-11), (c) tar-rubber concrete with tar-rubber binder B, and (d) tar-rubber concrete with tar-rubber binder A. All four pavements satisfactorily withstood the effects of heat and blast normally developed. The maximum measured surface temperatures of the pavements were 250-260 F. Critical erosion temperature for each type of pavement was determined by blasting with the tailpipe of the plane closer to the pavement (greater

than normal angle). The power cycle for this determination consisted of 5.5 minutes at idle power followed by the necessary time at 100 per cent power to effect erosion. The asphaltic concrete and tar-rubber pavement (a), (c), and (d) eroded at a maximum temperature of about 300 F. However, the tar concrete (b) eroded in a similar test when the temperature within the affected area ranged from approximately 225 to 275 F.

18. An inspection of the test area, actually a runway extension, after 18 months of traffic indicated some damage from blast in all of the test pavements, apparently as a result of erosion from use of afterburners during normal operations. The blast damage was quite severe in the tar-concrete where the maximum depth of erosion was as much as three-fourths of an inch, and less severe in the tar-rubber concrete, binders A and B, where the depth of erosion in the affected areas was nonmeasurable to one-eighth of an inch. The predominant types of planes were the F-89 (about 5062 cycles), T-33 (1520 cycles), a F-94 (500 cycles).

19. Fuel spillage. Incidental to the measurement of pavement temperatures, effects of jet-fuel (JP-4) spillage at the rate of 1.5 pt each time the engine was cut off were observed. There was no apparent softening of the tar or tar-rubber pavements and only slight softening of the asphaltic pavement after three cycles at each location. No stripping and only slight penetration were observed on the four pavement types. After 18 months, damage to the various types of test pavements as a result of jet-fuel spillage was observed to be negligible. The spillage was limited on the runway end.

20. Traffic. After 18 months of normal traffic from aircraft equipped with high-pressure tires, there was no evidence of rutting or shoving of any of the pavement items. However, observations showed pavement cracks varying in width from a hairline to one-eighth of an inch along the entire length of many surface-course construction joints (longitudinal with respect to direction of paving), and similar short cracks running longitudinally, transversely, and diagonally, but fewer in number, in the pavement proper. It was observed that most of the cracking occurred during, or immediately after, the second winter when traffic was about twice the traffic experienced during the first winter.

The cracking in the different surface courses was most pronounced in the tar-concrete and least pronounced in the asphaltic concrete. The pavement cracking as noted above is attributed basically to differential movements caused by frost action and to cold-weather placement of the pavements.

Waterways Experiment Station tests

21. Jet blast. A series of blast tests was conducted on five types of pavements having bitumen contents about optimum and plus and minus 10 per cent of optimum. The five pavements (listed below) were 12 months old at the time of test. A preliminary analysis of the test results indicates the resistance to blast of an F-80-B plane and the minimum erosion temperatures for the 12 pavement items tested to be as follows:

Type of Pavement (According to Binder)	Ability to Withstand Normal Maintenance Run-up of F-80-B Aircraft	Minimum Erosion Temp, F
Tar-rubber binder A Optimum minus 10 per cent	Satisfactory	+400
Binder A Optimum	Satisfactory	+400
Tar-rubber binder B Optimum minus 10 per cent	Satisfactory	375
Alabama asphaltic limerock Optimum	Satisfactory	340
Tar-concrete (RT-12) Optimum minus 10 per cent	Satisfactory	325
Tar-rubber binder B Optimum	Satisfactory	320
Asphaltic concrete Optimum minus 10 per cent	Satisfactory	315
Asphaltic concrete Optimum	Satisfactory	300
Asphaltic concrete Optimum plus 10 per cent	Satisfactory to unsatisfactory	290
Tar-rubber binder A Optimum plus 10 per cent	Unsatisfactory	285
Tar-rubber binder B Optimum plus 10 per cent	Unsatisfactory	275
Tar-concrete (RT-12) Optimum	Unsatisfactory	255

There were trends to indicate that the tar-rubber pavements became more resistant to erosion from jet blast with increased age and that high bitumen content and jet-fuel spillage lowered the resistance of the pavements to jet blast.

22. Fuel spillage. Accelerated fuel-spillage tests (rate of 1 qt JP-4 per cycle, up to four cycles per day, five days per week as determined by field survey) on similar pavements to those subjected to blast indicated the following:

a. The asphaltic-concrete and Alabama asphaltic-limerock pavement showed severe surface distress with three or more cycles of fuel spillage per day (testing period of 13 days).

b. The tar-concrete pavements appeared to be reasonably resistant to three or more cycles of fuel spillage per day (testing period of 50 days), but considerable fuel leaked into and in some cases through the 1-1/2-in. surface-course layer.

c. The tar-rubber pavements showed no serious detrimental effects from fuel spillage (also 50-day testing period). Leakage into the pavement was limited.

23. It should be noted that tar and tar-rubber pavements tend to harden, probably from oxidation, somewhat faster than asphalt pavements and to develop a surface that tends to become brittle; this hardening appears to be accelerated by jet-fuel spillage. Also, it is significant that two cycles of fuel spillage (that approximating refueling operations) do not appear to be detrimental to asphaltic-, tar-, or tar-rubber-concrete surfaces.

24. Traffic. Traffic tests conducted on pavements similar to those tested for blast (tests run in warm weather about three months after construction) showed that tar-rubber- as well as asphaltic- and tar-concrete pavements can be designed using recently developed Corps of Engineers criteria to resist rutting and shoving under traffic of 100,000-lb, dual-wheel load on tires of 200-psi pressure. The lean items, optimum minus 10 per cent, performed best under traffic. In some of the areas where jet fuel was spilled, subsequent accelerated traffic caused rather severe crazing of the brittle surface of the tar and tar-rubber pavements; in areas of no spillage, traffic also caused some crazing.

This crazing was confined to a surface thickness approximating one-eighth of an inch.

Davis-Monthan Air Force Base tests

25. Alert and maintenance aprons constructed of tar-rubber binder A and tar-rubber binder B were observed to be in very good condition 16 months after construction. However, the pavements have not been subjected to aircraft traffic up to the present time. Occasional light-truck traffic which has occurred in certain areas as a result of current construction in adjacent areas has had no apparent effect on the wearing surface. The only defects noted in the pavements were a few open cold longitudinal joints and a relatively small number of shrinkage cracks. Most of the cracks that have developed to date are in the tar-rubber binder B pavement. The majority of these cracks are of hairline width and do not appear to extend to any appreciable depth. All longitudinal joints, with the exception of the few open cold joints, appear to be very tight and show a smooth surface.

26. Jet-blast tests were conducted on the maintenance apron about nine months after construction with the new type fighter plane. Both tar-rubber pavements were subjected to pretake-off, maintenance without afterburner, and maintenance with afterburner blasts. Both pavements satisfactorily withstood the pretake-off and maintenance without afterburner blasts but eroded in less than 10 seconds under blast with the afterburner.

Williams Air Force Base tests

27. The tar-rubber pavement at Williams Air Force Base consists of tar-rubber binders A and B which were placed as a surface-course overlay over an asphaltic-concrete parking apron and taxiway. A visual inspection of the pavement was made 10 months after construction. During the 10-month period, the pavements were subjected to considerable use by light aircraft. The number of trips per month over the taxiway for T-33's and T-28's has been approximately 6000 and 3000, respectively. The parking apron pavements are used only by transient planes, which consist of approximately 600 jet trainers per month and 370 transports and light bombers per month.

28. The condition of the pavements at the time of inspection was considered good. The most severe damage consisted of cold longitudinal joints which had opened up and were showing a considerable amount of raveling in one area of the tar-rubber binder B pavement. Also, numerous hairline cracks up to one-sixteenth of an inch wide and approximately one-eighth of an inch deep were observed in the pavements at locations other than the joints. These appeared to be shrinkage cracks.

29. Another type of crack, which seemed to occur only in the tar-rubber binder B pavement, was found in areas where fuel had been spilled. The unique thing about the cracks was that they extended completely around the spillage area and occurred only where the surface had changed to a light brownish color. Only a few cracks of this type were located and they were of hairline width extending to very shallow depths of less than one-eighth of an inch.

30. Approximately 75 per cent of the apron area had, at some time or other, been used for parking as evidenced by the staining effect of fuel spillage. However, aside from the minor cracks discussed above, no detrimental effects from the spillage were evident. There were a few signs of surface erosion from jet blast in both tar-rubber pavements. However, the damage was not serious in any area. There was no indication of rutting or shoving in any of the pavement items.

Summation of Findings

31. The accelerated jet-blast, fuel-spillage, and high-pressure tire traffic tests on asphaltic-concrete, tar-concrete, and tar-rubber-concrete pavements and observations of actual field performance of these types of runway, taxiway, and apron surfacings, provided certain information. These data are listed below, arranged so as to group those concerning effects of traffic, spillage, and blast separately, since the latter are mainly individual design problems. Weathering of tar materials is also a problem that must be considered. Further, differentiation is required in some instances between the effect and the specific pavement facility under consideration. Finally, general conclusions are given.

Traffic

32. Asphaltic, tar, and tar-rubber pavements can be designed and constructed that will withstand the effects of 200-psi traffic.

Fuel spillage

33. Fuel spillage is detrimental to asphaltic concrete only where it is repeated at frequent intervals such as at fueling hydrants and parking areas. Fuel-resistant pavements are therefore needed at these locations.

34. Asphaltic-concrete and Alabama asphaltic-limerock pavement are not sufficiently resistant to the effects of repeated fuel spillage to be satisfactory for use in parking areas because of leaching of asphalt cement from the aggregate.

35. Tar concrete is resistant to the effects of repeated fuel spillage but showed high leakage and accelerated hardening of the tar.

36. Tar-rubber concrete will resist the effects of repeated fuel spillage.

Heat and blast

37. Jet heat and blast are detrimental to bituminous pavements only if the binder is heated to the point where the aggregate is eroded by the blast. Tests to date indicate that approximately 250 F is the critical point of heat for tar, and approximately 300 F for asphaltic concrete and tar-rubber. In the tests the tar-rubber pavements showed a minimum erosion temperature of 315 F, but this is not considered high enough to rate the material as significantly better than asphaltic concrete.

38. Without afterburners. Maximum temperatures induced in tests simulating pretake-off checks at ends of runways were less than 300 F (includes consideration of the new type jet fighter). Either asphaltic concrete or tar-rubber will withstand these temperatures without eroding.

39. Maximum temperatures induced in tests simulating maintenance run-ups in parking areas were less than 315 F (except for the B-45 which is considered obsolete). Tar-rubber pavements will withstand these temperatures. Asphaltic concrete will also generally withstand these temperatures, but as noted previously, would be subject to detrimental

damage where subjected to repeated fuel spillage.

40. With afterburners. Maximum temperature induced by test simulating pretake-off check at end of runway with the new jet fighter was 350 F. This temperature for the one- to two-second period used in the simulated test produced no erosion in the asphaltic-concrete or tar-rubber pavements at Davis-Monthan.

41. Field inspections have revealed erosion at ends of runway which has been attributed to F-89 and to B-47 planes. Tests at Eglin indicate that the F-89 produces a maximum pavement temperature of 175 F during pretake-off check without afterburner; therefore, eroded places at ends of runways are attributed to operation of the F-89 with afterburner while plane is sitting still. Temperatures produced under these conditions are estimated at 350 F. Limited erosion has been noted from the outboard engines of the B-47. In tests at Eglin this engine produced temperatures of 213 F in the pretake-off checks and 315 F in the maintenance run-up. Apparently the checks at the end of the runways are approaching maintenance run-ups in time.

42. Simulated maintenance run-up with the new jet fighter with afterburner operating produced temperatures of 685 F. None of the bituminous materials tested can withstand these temperatures without erosion.

Weathering

43. Tar pavements harden with age and tend to become brittle at the surface. The addition of rubber to the tar tends to alleviate the hardening to a slight degree.

44. Fuel spillage accelerates the hardening and in some cases produces a brittle surface (one-fourth of an inch deep) which develops crazing under traffic.

45. Hardening occurred in all tar and tar-rubber pavements within six months. Pavements at the Waterways Experiment Station have shown little change in the past 24 months (they are now 30 months old).

46. Cold longitudinal joints have opened, and minor surface cracking has been observed in tar-rubber pavements at Presque Isle, Davis-Monthan, and Williams Air Force Bases. This cracking is undesirable

but, up to the present time, is not considered serious.

Conclusions

47. The following conclusions are based on high-quality pavements designed and constructed to meet current Corps of Engineers specifications. The conclusions take into consideration recent tests with a new jet fighter.

a. Tar concrete is not considered satisfactory, primarily because it erodes under jet blast at low temperatures.

b. Asphaltic concrete will give satisfactory performance under traffic and blast of jet planes, except in areas where afterburner checks are made. Occasionally the outboard engine of the B-47 and the new jet fighter may produce minor erosion. Asphaltic concrete will also give satisfactory performance under the incidental fuel spillage that occurs on taxiways, runways, and aprons, but will not withstand the repeated spillage in parking areas.

c. Tar-rubber pavements will give satisfactory performance under traffic, spillage, and blast of jet planes, except in areas where afterburner checks are made (see note). (Note: Conclusion c is qualified to the extent that the effects of age are not fully known. All tests were conducted on relatively new pavements. The most extensive testing was conducted on pavements at the Waterways Experiment Station which are now 30 months old. Effects of age were apparent at 6 months, but have not increased appreciably in the last 24 months.)

d. None of the bituminous pavements would resist erosion in the areas where afterburner checks are made. (It is not within the scope of this study to evaluate the ability of portland-cement concrete to withstand the effects of afterburner checks.)

Appendix A

INTERIM SPECIFICATION FOR TAR-RUBBER BLEND FOR USE AS BINDING AGENT IN HOT-MIX TAR-RUBBER PAVEMENT

4 August 1954
Revised 5 November 1954

A. SCOPE

A-1. This specification covers tar-rubber blends for use as binder in hot-mix tar-rubber pavements.

B. GENERAL REQUIREMENTS

B-1. The tar-rubber blend shall consist of a mixture of unvulcanized synthetic rubber, suitable plasticizers, and other necessary ingredients, blended with high-temperature coal tar of the coke-oven variety, conforming to Federal Specification RT-143. The rubber shall be of a type which is resistant to petroleum oils and distillates. The tar-rubber blend shall contain a minimum of 3 per cent by weight of rubber hydrocarbons. Water-gas tars shall be excluded although they meet Federal Specification RT-143. The blend shall be homogeneous, free of lumps and strings, and capable of being introduced into the mixing plant in accordance with regular practice.

B-2. Subject to approval by the contracting officer, the rubber additive, in either liquid or solid form, may be blended with the tar at the paving plant or at a supplier's plant. In either case, the contractor shall permit inspection by government inspectors during the mixing and blending process when deemed necessary by the contracting officer. The contractor shall be furnished a certificate of the type and quantity of rubber hydrocarbons added to the blend when required by the contracting officer.

C. PREPARATION OF TEST SAMPLE

C-1. Approximately 800 g of the tar-rubber blend shall be melted in a double-boiler-type laboratory melting unit as described in paragraphs E-1, 2, and 3.

C-2. The tar-rubber blend shall be stirred continuously by mechanical means during the melting operation. Frequent temperature observations should be made to assure holding the material within the specified temperature limits.

C-3. The pouring temperature of the blend shall be 235 ± 10°F. The temperature of the blend during melting shall not exceed 245°F and the temperature of the oil bath shall not exceed 275°F. The melting time shall not exceed 60 minutes.

D. TEST REQUIREMENTS

D-1. Penetration

D-1a. Before immersion in fuel

(1) Two penetration samples shall be prepared in accordance with Federal Specification SS-R-406, Method No. 214.01 (ASTM D-5-49).

(2) Initial penetration shall be determined on one penetration sample at approximately the same time as the penetration is determined on the immersed sample in accordance with penetration procedure described in Federal Specification SS-R-406, Method No. 214.01. Penetration shall not be less than 100 nor more than 225.

D-1b. After immersion in fuel

(1) The second penetration sample shall be immersed in synthetic fuel, as described in ASTM Method of Test D471-49T as reference fuel No. 2, for a period of 18 hours during which time the fuel shall be maintained at a constant temperature of 100 ± 2°F.

(2) Upon completion of the soaking period the specimen shall be removed from the fuel and dried under forced draft at room temperature for one hour.

(3) At the completion of the drying period, a penetration shall be made in accordance with SS-R-406C, Method No 214.01.

(4) Penetration after immersion in the specified fuel shall not be less than 100 nor more than 250, nor shall the difference between the nonimmersed and the immersed penetration exceed 50.

D-2. Volume and weight change during immersion in fuel

D-2a. Before immersion in fuel

(1) A portion of the sample prepared in paragraph C above shall be poured into a metal container (seamless ointment box) approximately 2-1/8 in. in diameter and 1-1/4 in. deep. The depth of the material

in the container shall be approximately 1 in.

(2) This sample shall be allowed to cool in an atmosphere at a temperature not higher than 85°F and not lower than 70°F for not less than 1-1/2 nor more than 2 hours. The sample shall then be weighed in air.

(3) The sample shall then be placed in a water bath maintained at a temperature not varying more than 0.2°F from 77°F where it shall remain for not less than 1-1/2 nor more than 2 hours.

(4) At the end of the above period in the water bath the sample shall be weighed in water at the same temperature as the water bath, i.e., 77 ± 0.2°F.

(5) The difference between the weight in air and the weight in water shall be determined and recorded as the volume of the sample plus container in cubic centimeters before immersion in fuel.

D-2b. <u>After immersion in fuel</u>

(1) After the weight in water is obtained, as shown in paragraph D-2a(4) above, the sample shall be dried with a clean, dry cloth and immersed in synthetic fuel along with the penetration specimens as described in paragraph D-1b(1) above.

(2) The sample shall be removed from the fuel and dried under forced draft at room temperature along with the penetration sample as described in paragraph D-1b(2) above.

(3) At the completion of the drying period the sample shall be again weighed in air and in water following steps D-2a(2), (3), and (4) above.

(4) The difference between the weight in air and the weight in water shall be determined and recorded as the volume of the sample plus container in cubic centimeters after immersion in fuel.

(5) The volume of the sample (plus container) shall neither increase nor decrease more than 2.5 per cent after soaking in the specified fuel.

(6) The dry weight of the specimen (plus container) shall neither increase nor decrease more than 2.0 per cent after soaking in the specified fuel.

D-3. Flow

D-3a. A portion of the sample prepared in paragraph C above shall be poured into an amalgamated mold 4 cm wide by 6 cm long by 0.32 cm deep, placed on a bright tin panel. The mold shall be filled with an excess of material, allowed to cool to room temperature for at least 1/2 hour, and then trimmed flush with the face of the mold with a metal knife or spatula. The mold shall then be removed, and the panel containing the sample shall be placed in an oven maintained at 100 $\pm$ 2°F for 60 minutes. During the test the panel shall be so mounted that the longitudinal axis of the specimen is at an angle of 75 $\pm$ 1 degree with the horizontal, and the transverse axis is horizontal.

D-3b. The change in length of the specimen during the 60-minute test period shall not exceed 4 cm.

D-4. Softening point

D-4a. The softening point of the blend shall be determined in accordance with Method No. 216.0, as described in Federal Specification SS-R-406 (ASTM D36-26).

D-4b. The softening point as determined in accordance with paragraph D-3a above shall not be less than 90°F (32.2°C).

D-5. Viscosity

D-5a. The viscosity shall be determined by use of a Brookfield viscosimeter, Model LVF, under the following specified conditions and with the reading being taken 60 seconds after spindle is actuated.

Temperature, °F	Spindle No.	RPM
200	4	6
225	4	6
250	2	6

D-5b. The viscosity in Brookfield units as determined in paragraph D-5a shall be within the following limits:

Temperature, °F	Brookfield Units
200	4,000 - 15,000
225	1,750 - 7,000
250	800 - 3,000

D-6. Water content

D-6a. The water content of the tar-rubber blend shall be determined in accordance with the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials, ASTM Designation: D95-40.

D-6b. The water content as determined in paragraph D-6a shall not exceed zero.

E. TESTING EQUIPMENT

E-1. The unit for melting laboratory samples shall be of the double-boiler type employing a high flash point oil as the heat transfer medium. It shall be so designed and built that the oil shall completely surround the sides of the inner or material chamber.

E-2. The melting unit shall be equipped with a bottom discharge or opening controlled by a knife or blade valve to permit drawing off melted material.

E-3. Provision shall be made to install a mechanical agitator in the material chamber or chambers.

E-4. Provision shall be made for thermometers to read temperatures of both the tar-rubber blend and the heat-transfer oil.

An

Suggested Paragraph Regarding Field Test Panels

Initial laboratory tests for acceptance of a proposed material will be performed by the Waterways Experiment Station. In addition, a field test panel will be constructed and subjected to repeated spillage of jet fuel for materials which have not been previously field tested. The results of the repeated spillage tests will be a part of the acceptance tests. It is believed that materials meeting the laboratory performance tests will perform satisfactorily under repeated spillage, but the contractor is warned that present knowledge of tar-rubber materials does not permit assurance that materials meeting the laboratory performance test will show satisfactory performance under repeated spillage.

One hundred and fifty gallons (150) of the proposed tar-rubber blend produced in full-scale production operations shall be furnished for these tests which will require 35 days. (Since testing will be outdoors, inclement days will not be counted.) Following these acceptance tests, control samples shall be taken throughout the period of the work and subjected to the laboratory performance tests at regular intervals in order to control production of the material.

The cost of both laboratory and field performance tests shall be borne by the government where the material meets specification requirements. The contractor shall bear the cost of laboratory and field performance tests on materials that do not meet specification requirements.